Toward a common nuclear safety culture: from knowledge creation to competence building in Euratom programs

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SUMMARY AND KEY MESSAGES*

One of the main goals of the Euratom research and training programs is to contribute to the sustainability of nuclear energy by providing resources, in particular, for research and innovation in Generations II, IIII and IV (knowledge creation). Euratom training programs contribute most notably to competence building while facilitating the mutual recognition of experts and thereby continuously improving the nuclear safety culture. The Sustainable Nuclear Energy Technology Platform (SNE-TP), composed of all stakeholders of nuclear fission and radiation protection (over 75 organizations), is a driving force therein.

The emphasis in this paper is on nuclear competence building under the current 7th Euratom Framework Programme (2007-2013). The employers (in particular, the nuclear industry and the technical safety organisations) are naturally involved in this process. According to the IAEA definition, *competence means the ability to apply knowledge, skills and attitudes so as to perform a job in an effective and efficient manner and to an established standard* (S.S.S. No. RS-G-1.4/2001). Knowledge is usually created in higher education institutions (e.g., universities) and in (private and public) research organizations. Skills and attitudes are usually the result of specific training and on-the-job experience throughout professional life.

Euratom training activities are traditionally addressed to scientists and experts with higher education. Special attention is devoted to the continuous improvement of their competencies through borderless mobility and lifelong learning in synergy with the main stakeholders. The Euratom training strategy is based on three objectives:

1 – Analysis of the *needs of society and industry* with regard to a common nuclear safety culture. This issue raises important questions, for examples: What should be added to existing training schemes ? How could Continuous Professional Development (CPD) be improved ? Is mobility and mutual recognition of experts important ? (especially in the areas of reactor safety and performance; waste management; and medical applications of ionising radiations)

2 – Convergence toward a *common vision* that puts the above needs in a European Union (EU) perspective. This means, for example: pursue ambitious goals in the new CPD approach, while satisfying hard constraints (e.g., continuous improvement of sustainability, safety and reliability, economic performance, and proliferation resistance of nuclear energy – those are also the four goals underpinning the strategy of the Generation IV International Forum /GIF/).

3 – Development of common instruments that meet the above needs and vision (ECVET). This necessitates, for examples: a common "taxonomy" of competencies linked to tasks in the nuclear industry; the definition of "learning outcomes" that are recognized throughout the EU, and thereby facilitate borderless and lifelong learning; the identification of "competent institutions" to provide portfolios of learning outcomes required to perform the above tasks.

1. INTRODUCTION

Nuclear energy has played an important role in the production of electricity during the past half-century. In 2009, worldwide, 436 Nuclear Power Plants (NPPs) with a total output capacity of 370 GWe in 30 countries, plus Taiwan, supplied about 15 % of all electric power produced on the planet. Nuclear power represents 6 % of the global primary energy demand. In the EU, nuclear fission provides more than 30% of electricity power, which in turn constitutes 14% of the global primary energy demand. Some EU countries, such as Finland and France, have begun the construction of new NPPs, particularly of the Generation III type. Other EU Member States as well as other countries in the world (especially in East Asia) are likely to do the same. Altogether, this constitutes what is known as the "Nuclear Renaissance". At

* Resumen en español al final del artículo.

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the Horizon 2050, nuclear power worldwide could expand by a factor of nearly 4, according to a study by the Nuclear Energy Agency (OECD/NEA), designated "Nuclear Energy Outlook, 2008" (figure 1).

Nuclear technology is multi-disciplinary, covering nuclear and reactor physics, thermal hydraulics and mechanics, materials science, chemistry, health science, information technology and a variety of other areas such as risk governance and education and training (E&T). Mankind enjoys many benefits from nuclear-related technologies, most notably electricity production. Advances in health care and medicine as well as industrial measuring methods are also increasingly dependent upon expertise in applications of ionising radiations.

Nuclear technology activities thus require a great deal of expertise in engineering and science. For generations to come, electrical, medical and other applications of ionising radiations will continue to require highly educated nuclear experts. A key concern of industry and policy makers, however, is that human resources could be at risk, especially because of high retirement expectations in "old" countries and a lack of nuclear experience in "new" countries.

In "old" countries with nuclear installations – whether for power generation or for medical applications – highly qualified people are needed to operate the existing installations in order to deal with radiation protection issues and to manage radioactive waste. This is also true for "new" countries introducing nuclear power programs, such as the more than 50 Member States of IAEA that have approached the agency expressing similar interest. As a reminder, the United Arab Emirates (UAE), led by Abu Dhabi, confirmed in December 2009 their contract with a South Korean consortium for the construction and operation of four reactors with a production capacity of 1400 MWe each (APR-1400 of KEPCO, of the Generation III type).

Technological performance in industry can only be ensured, while maintaining the required level of safety and security, if a sufficient number of highly qualified staff is available over a long time period. (Bear in mind that the life cycle of new NPPs covers a period of more than 100 years, from design and construction to full dismantling.) Similar concerns are expressed by other nuclear stakeholders, such as safety regulators and the medical sector that uses ionising radiations. For that reason, it is generally believed that broad and deeply rooted research and training programs – at both national and international levels - are essential to the proper mastering of the science and technologies used in the nuclear domain.

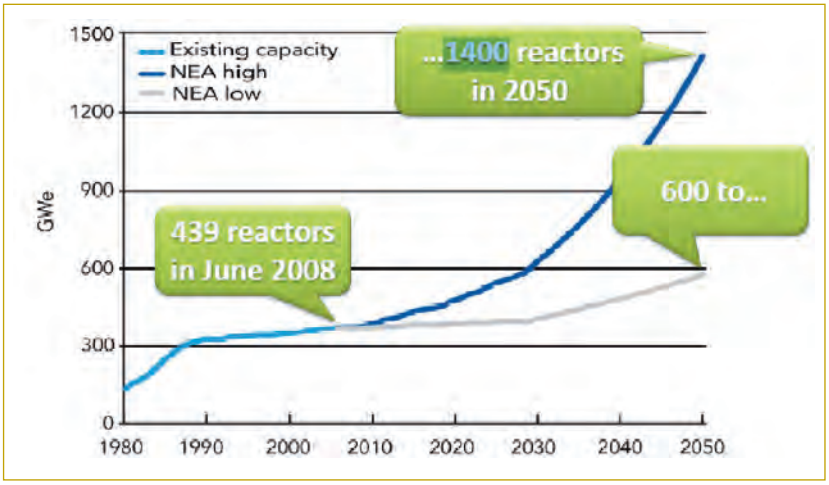

Figure 1: global nuclear capacity in the OECD/NEA high and low scenarios.

Worth recalling here is the Euratom treaty signed in 1957. The second title sets out the *provisions to encourage progress in the field of nuclear energy (promotion of research, dissemination of information, health and safety safeguards...external relation*). This paper seeks to show how Euratom training activities contribute, in particular, to the continuous improvement of nuclear competencies by supporting borderless mobility across the EU and lifelong learning. In keeping with the IAEA definition, *competence means the ability to apply knowledge, skills and attitudes so as to perform a job in an effective and efficient manner and to an established standard* (Safety Standards Series No. RS-G-1.4/2001). One of the aims of Euratom is to better meet the end-users needs, that is to say: satisfy the competence requirements put forward by systems suppliers and energy providers, nuclear regulatory authorities and TSOs, universities, public and private research organisations, etc.

2. EUROPEAN CREDIT SYSTEM FOR VOCATIONAL EDUCATION AND TRAINING (ECVET)

For the reasons explained in the Introduction, special attention is devoted in the nuclear community to the continuous improvement of competence building (as a step beyond traditional education & training and knowledge management /ETKM/). More generally, competence building is the result of traditional education plus life-long learning, non-traditional learning, and other forms of educational experiences, relying, in particular, on borderless mobility across the EU and abroad to get acquainted with various sectors.

Within the EU the demonstration of professional know-how and the international recognition of competencies become thus key issues. The principal question asked of the graduate or the young professional will therefore no longer be "*what did you do to obtain your degree (or your qualification)?*" but rather "*what can you do now that you have obtained your degree (or your qualification)?*"

As a consequence, a new concept is emerging in the Vocational Education and Training (VET) community, including also academic experts, namely: the "learning outcomes", assessed and recognized throughout the EU. In principle, "learning outcomes" should be achievable through a variety of education and training paths (be they in a formal, non-formal or informal context) for individuals who are following a learning process to acquire specific competencies in a nuclear sector. Learning outcomes are gaining in importance compared to the traditional input-led evaluation, based on textbook knowledge or end of course examination. In practice, learning outcomes refer to specific competencies and therefore consist of a mix of Knowledge (Learning to know), Skills (Learning to do) and Attitudes (Learning to live together and/or Learning to be), to be defined by all stakeholders concerned.

The above reflections are at the basis of the *European Credit system for Vocational Education and Training* (ECVET/Copenhagen Declaration, 2002)–see details in the *Recommendation of the European Parliament and of the Council* of 18 June 2009 [1]. ECVET's objective is to promote mutual trust, transparency and recognition of competencies and qualifications in VET across the 27 EU Member States, and is concerned with education and training systems and different types of institutions. Following the ECVET definition, "learning outcomes" means statements of what a learner knows, un-

derstands and is able to do on completion of a learning process; they are defined in terms of knowledge, skills and attitudes. ECVET is aimed at facilitating the transfer, recognition and accumulation of assessed learning outcomes of individuals on their way to achieving a qualification or a "*European Passport*". ECVET integrates existing instruments into a single framework that should be implemented by all EU Member States by 2012 (e.g., ECTS, European CV, Europass, EQF).

ECVET provides also complementary information about qualifications and units in numerical form. They have no value independent of the acquired learning outcomes for the particular qualification to which they refer and they reflect the achievement and accumulation of units. To enable a common approach for the use of ECVET points, a convention is used according to which 60 points are allocated to the learning outcomes expected to be achieved in a year of formal full time VET. The 60 ECVET points seem analogous to the 60 ECTS points for higher education (Bologna Declaration, 1999, ERASMUS program). There is however a big difference: ECVET is based on learning outcomes, whereas ECTS is based on time spent in course and/or in laboratory exercises.

It is worth insisting that ECVET is not meant to replace the national systems, but rather to promote the improvement of flexibility and mobility among existing systems, that is to say: reduce the "barriers" against mutual recognition of experts throughout the EU. In countries where there is already a national system to develop high level skills using points, the relevant competent institutions establish arrangements for the conversion of national credit points to ECVET points. For example, in the UK, there is a system, named "*National Skills Academy*": the *National Skills Academy Nuclear* is rolling out a "*Nuclear Skills Passport*" with its own accreditation system. Such systems, which rely on national "competent institutions", and the possible links to ECVET are discussed at the Euratom level.

An interesting application of ECVET at the higher education level is the report produced by one of their leading projects: "*Writing and Using Learning Outcomes: a Practical Guide*" [2]. This report presents a summary of developments in curriculum design in higher education in recent decades and, drawing on recent practical experience, suggests a user-friendly methodology for writing modules, courses and programmes in terms of learning outcomes.

The EU policy for Continuous Professional Development, including ECVET, is developed by the EC Programme on Lifelong Learning (DG Education and Culture/Leonardo da Vinci); general information and specific questions and answers are on their website [3] .

3. PLATFORMS TO GUIDE EURATOM RESARCH AND TRAINING (SET Plan, SNE-TP, ect.)

Nuclear fission is an integral part of the energy mix policy of the EU: the three primary energy sources (fossil, renewable and fissile) are discussed in the integrated "Energy and Climate Change" policy [4] of the EU. It proposes a sustainable, low-carbon, energy-efficient economy, in particular through the ambitious "Objectives 20/20/20 for 2020" fixed by the EU Council in March 2007.

Nuclear fission, in particular, is discussed in several forums or platforms, most notably in the *Sustainable Nuclear Energy Technology Platform* (SNE-TP [5]), launched in September 2007; it aims at promoting research, development and demonstration that will maintain excellence in fission technology and provide long-term waste-management solutions. Since November 2009, the SNE-TP is composed of over 75 organizations from 17 countries (16 EU members and Switzerland). In May 2009, they published a Strategic Research Agenda. They presented their Deployment Strategy in May 2010. Worth mentioning, in this context, is their Working Group on Education, Training and Knowledge Management (ETKM).

Another important contributor to Euratom energy policy and legislation is the *European Nuclear Forum Energy* (ENEF [6]), launched in November 2007. One of its working groups also deals with training. With regard to the need for having better knowledge of the skills gaps in the EU nuclear industry, the ENEF created a European *Human Resources Observatory Nuclear Energy* [7] (EHRO-N). The research strategy for radiation protection is in the hands of the platform *Multidisciplinary European Low Dose Initiative* (MELODI [8]). Finally, with regard to safety enforcement, there is the *European Nuclear Safety Regulators Group* (ENSREG[9]), launched in October 2007, which is composed of senior officials from national nuclear safety authorities; it focuses on nuclear safety, waste management and spent fuel.

In November 2007, the European Commission (EC) published a *European Strategic Energy Technology Plan* (SET Plan), which was endorsed by the EU Energy Council in February 2008. Based on wide consultation across the EU, the Community then proposed to launch a number of *European Industrial Initiatives* (EIIs) that cover both energy efficiency and clean applications of primary energy sources. The *European Sustainable Nuclear Industrial Initiative* (ESNII) - to be launched on 15 November 2010 at the SET Plan Conference in Brussels - will address, in particular, the need for demonstration of Generation-IV Fast Neutron Reactor technologies, together with the supporting research infrastructures, fuel facilities and research work. The ESNII is part of the above mentioned GIF strategy.

Worth mentioning in this context as well is the declaration of European Commission (EC) President José Manuel Barroso, at the *International Conference on Access to Civil Nuclear Energy* (Paris, 8 March 2010):

"We are convinced that the new sustainable economy of the EU requires notably decarbonising our electricity supply. Renewable energies should take a leading role in doing so. But nuclear power can complete the range of low-carbon energy options. To create the conditions of a safe, sustainable and optimal use of civil nuclear power, the issue of radioactive waste in particular should be tackled."

4. OBJECTIVES FOR EURATOM EDUCATION AND TRAINING PROGRAMS

Keeping the nuclear option open means maintaining an adequate skills base to ensure sufficient personnel in research organizations and in nuclear installations. Nuclear education and training is a concern shared not only by international organisations such as OECD/NEA and IAEA, but also by the EC (EU Competitiveness Council of 1 - 2 December 2008) [10] .

One of the main goals of the Euratom research and training programs is to contribute to the sustainability of nuclear energy by providing resources, in particular, for research and innovation in Generations II, IIII and IV (knowledge creation). Euratom training programs contribute most notably to competence building while facilitating the mutual recognition of experts and thereby continuously improving the nuclear safety culture.

Knowledge is usually created in higher education institutions (e.g., universities) and in (private and public) research organizations. Skills and attitudes are usually the result of specific training and on-the-job experience throughout professional life (in particular, in the nuclear industry and technical safety organisations). Twenty-five years of Euratom research and training programs (from the first Framework Programme, FP-1,

in the mid-1980s, to the current FP-7) and the guidance provided by the above EU platforms have helped continuously to improve the required nuclear expertise. This is always done in close synergy with the main stakeholders.

The stakeholders in nuclear fission and radiation protection include:

- research organisations (e.g., public and private sectors, power and heat applications)
- systems suppliers (e.g., nuclear vendors, engineering companies)
- energy providers (e.g., electrical utilities, co-generation plants for process heat)
- nuclear regulatory bodies and associated technical safety organizations (TSOs)
- higher education and training institutions, in particular universities
- civil society (policy makers and opinion leaders) and various NGOs.

For the sake of clarity, education and training are defined as follows (ENEN [11]):

Education is a basic and life-long learning process. Education is broader than training, encompassing the need to maintain completeness and continuity of expertise across generations. It is essentially a *knowledge creation* process, involving academic institutions as suppliers and students as clients; it deals mainly with knowledge (and understanding).

Training involves learning a particular skill or attitude required to perform a specific job, usually to an established standard. It is concerned with schooling activities other than regular education programs and is essentially a *competence-building* process, involving VET providers and academic experts as suppliers and professionals as clients; it is mostly about skills and attitudes in addition to knowledge (competencies).

Euratom training activities are traditionally addressed to scientists and experts with higher education. Special attention is devoted to the continuous improvement of their competencies through borderless mobility and lifelong learning. The Euratom training strategy is based on three objectives, explained below in Sections 4.1, 4.2 and 4.3:

- analysis of the *needs of society and industry* with regard to a common safety culture.
- convergence toward a *common approach* that puts those needs in an EU perspective
- development of *common instruments* that meet the above needs and vision (ECVET).

4.1. Analysis of the *common needs* of society and industry

Here are examples of the *common needs* of society and industry, related to sustainability in nuclear activities: What should be added to existing training schemes? How could Continuous Professional Development be improved? Is mobility and mutual recognition of experts important? (especially in the areas of reactor safety and performance; waste management; and medical or industrial applications of ionising radiations).

Common needs for nuclear competence building are treated in many national and international fora (in particular, the above mentioned SNE-TP, ENEF, MELODI and ENSREG). In this regard, it is also worth recalling Article 7 of the "Nuclear Safety Directive" (EU Council, Brussels, 25 June 2009 [12]), devoted to "expertise and skills in nuclear safety":

"Member States shall ensure that the national framework in place requires arrangements for education and training to be made by all parties of their staff having responsibilities relating to the safety of nuclear installations in order to maintain and to develop further expertise and skills in nuclear safety."

This EU Directive constitutes a major step toward achieving a common, legally binding framework and a strong nuclear safety culture in the EU.

Euratom research is generally user-driven, as opposed to basic research (usually conducted at the national level), which is more knowledge-driven. The end-users of the findings should be clearly identified right from the start of each project. They can, for example, be plant operators or safety authorities, not necessarily directly involved as scientists participating in the project consortium. The project's objectives should be of the pre-competitive type; no commercial issue should obstruct fair collaboration within the consortium. This is sometimes referred to as "*coopetition*," a neologism coined to describe a challenging mix of cooperation and competition. Of particular interest are Euratom FP-7 projects aimed at harmonizing best practices in order to continue the improvement of the common nuclear safety culture.

Because of the very peculiar competencies needed in some jobs, the following need has been expressed by the nuclear stakeholders: the mobility of learners and the flexibility of learning pathways to achieve the required qualifications or portfolios of learning outcomes. This requires, however, a special effort from the stakeholders regarding internships for learners. An internship is an opportunity to work within an organization that you would otherwise need a degree or a special qualification to hold a position in. International collaboration outside the EU is welcome because it contributes to attracting learners while increasing their mobility.

In keeping with the ECVET approach introduced in Section 2, the following issues require a particular attention:

(1) a common language for competencies and education and training related to nuclear fission and radiation protection. This is sometimes called a common "taxonomy" of competencies and occupations linked to nuclear tasks and jobs. Etymologically, taxonomy is the practice and science of classification. The development of a well structured common terminology across the EU for the description of nuclear competencies and jobs needs a lot of conceptual work. This would then enable the specification of agreed learning outcomes and assessment criteria. All stakeholders concerned with human resources and professional recruitment in the nuclear community are invited to participate in this exercise.

(2) the definition of "learning outcomes" that are recognized throughout the EU, and thereby facilitate borderless and lifelong learning. Pilot exercises are necessary to apply the "learning outcomes" approach within ECVET partnerships. Following the ECVET approach, partnerships are formed between Home Institutions and Hosting Institutions. The Home Institution will validate and recognise learning outcomes achieved by the learner. It is the home institution that sends the learner out and where the learner returns. The Hosting Institution delivers training for the learning outcomes concerned and assesses the achieved learning outcomes.

(3) the identification of "Competent Institutions" or "Competent Bodies" in the EU to provide qualifications (wherever they are required by national or EU nuclear regulations) or portfolios of learning outcomes (desired, for example, in the case of the nuclear "*European Passport*", envisioned in some Euratom FP-7 training projects). A competent institution means an institution which is responsible for designing and awarding qualifications or recognizing units or other functions linked to ECVET, such as allocation of points to qualifications, assessment, validation and recognition of learning outcomes, under the rules and practices of participating countries. A competent institution could be a Ministry, a university, a nuclear regulatory authority, a Qualifications and Curriculum Development Agency, a Skills Body or any association which is recognised in practice as "competent".

4.2. Convergence toward a *common vision* within the EU

Here is an example of a *common vision* that puts the needs discussed above in an EU perspective: pursue ambitious goals in the new CPD approach, while satisfying hard constraints (e.g., continuous improvement of sustainability, safety and reliability, economic performance, and proliferation resistance of nuclear energy – those are also the GIF goals).

Euratom programs contribute to the continuous improvement of technological or regulatory applications in all sectors of nuclear energy and radiation protection, that is to say: reactor safety and performance; waste and spent fuel management; and medical or industrial applications of ionising radiations. Technology and regulation, however, are usually not sufficient to ensure the safe operation of nuclear systems, be it hardware (e.g., systems and components) or software (e.g., instrumentation and control). An outstanding nuclear safety culture is necessary, based on *skills* and *attitudes* that go well beyond *knowledge*.

After the 1986 Chernobyl accident, the notion of a safety culture took root in the International Nuclear Safety Group [13] (INSAG) of the IAEA. In one of their reports, INSAG maintains that the establishment of a strong safety culture within a nuclear facility is one of the fundamental management principles needed for safe operation. The INSAG definition recognizes that *"safety culture has two general components. The first is the necessary framework within an organization and is the responsibility of the management hierarchy. The second is the attitude of staff at all levels in responding to and benefiting from the framework."* This is true for nuclear plant operators in industry as well as for radiation physicists in hospitals or scientists in nuclear laboratories. The international safety concern is summarized in the notable warning: *"A (severe) nuclear accident anywhere is an accident everywhere."*

As a result, training schemes are continuously improved and new specific competencies are created wherever necessary in the nuclear sectors. The emphasis is on the additional knowledge, skills and attitudes that are required to improve, world-wide, a common nuclear safety culture in a variety of sectors ranging from nuclear power and fuel manufacturing plants to medical applications of ionising radiations. As is noted in many Euratom projects, basic concepts such as ALARA ("As Low As Reasonably Achievable") are interpreted in different ways in different sectors. A common understanding of the ALARA principle is a matter of both research (e.g., optimisation of the interface between man, technology and organization /MTO/) and training (e.g., sharing practical experience on accident analysis and management).

When it comes to structuring a common vision along the lines of ECVET, special attention should be paid in new nuclear training schemes to the design of appropriate "learning outcomes" at the EU level. They should aim at responding to the requirements of specific professional tasks, as they are put forward by the end-users, that is to say: systems suppliers and energy providers, nuclear regulatory authorities and TSOs, universities, (public and private) research organisations, etc. In addition, the competencies resulting from the proposed learning processes should be as much as possible in line with the above mentioned GIF goals.

4.3. Development of *common instruments* to meet this vision

Here are examples of *common instruments* needed to meet the above needs and vision (ECVET): a common "taxonomy" of competencies linked to tasks in the nuclear industry; the definition of "learning outcomes" that are recognized throughout the EU, and thereby facilitate borderless and lifelong learning; the identification of "competent institutions" to provide portfolios of learning outcomes required to perform the above tasks.

External funding, of course, is another important instrument. At the EU level, it is worth citing the Community's shared-cost scheme (FP-7), under which a project's funding is generally shared equally by the EU (50 %) and the consortium participants (50 %). The knowledge generated during a FP-7 contract belongs to all the participants (not to the EU). The intellectual property rights policy is decided within the consortium. To ensure the sharing of the knowledge created in large FP-7 projects, a special effort is made for education and training; usually 5 % of the total budget is reserved for training activities.

Also important is the existence of national education and training networks. Mobility of learners, flexibility of learning pathways and networking of competencies, preferably first at the national and then at the EU level, are particularly important to ensure constant improvement of the competencies needed with regard to the common nuclear safety culture.

Advanced numerical simulation techniques in EU research projects are also an efficient instrument for competence building, in particular, in connection with safety analysis reports. Well-validated numerical simulation codes, with good predictive capabilities, contribute also to Nuclear Knowledge Management (NKM). They are even believed to provide one of the most efficient tools in NKM. They are useful in understanding complex phenomena in theory and in preparing full-scale applications for innovative technologies, whether for nuclear power systems (e.g., Generation IV) or for special applications of ionising radiations.

Finally, the so-called "European added value" of a Community project can be defined simply as *"the whole is bigger than the sum of its parts"*. An important criterion of successful Euratom research and training projects is the dissemination of results of common EU interest. This can be best measured by the so-called multiplication factor, that is to say: on average, the partners in a Community project obtain access to a knowledge base worth up to 10 times their own financial contribution. Another criterion of success is the number of commercial or regulatory applications that result from joint findings after the contractual deadline.

5. THE EUROPEAN NUCLEAR EDUCATION NETWORK (ENEN) AND ECVET

To ensure the highest quality in nuclear education and training across the EU, a non-profit association was formed in September 2003 (under a 1901 French Law). This legal entity (located at CEA-INSTN Paris) is the *European Nuclear Education Network (ENEN*[11]). One of ENEN's major objectives is to restructure educational schemes in modules along the ECTS lines and to restructure training schemes in terms of learning outcomes along the ECVET lines. As of June 2010, the ENEN association had 56 members from 17 EU Member States, plus Switzerland, South Africa, the Russian Federation, Ukraine and Japan). ENEN is also open to further international collaboration: it has signed external Memorandums of Understanding (e.g., with South Africa, Russia and Japan) and partnership agreements (e.g., with ENS, IAEA/ANENT, Canada and WNU). A special agreement has also been signed with the Joint Research Centre (DG JRC) in the area of training in safeguards and nuclear security.

The Euratom approach to nuclear education is in fact quite in line with the Bologna Declaration (1999 / European Area of Higher Education), which is the basis of the European Credit Transfer and Accumulation System (ECTS), commonly known as the ERASMUS program. The Euratom approach focuses on the

creation of teaching modules that can be assembled into Masters programs jointly qualified and recognized across the EU. Education activities are usually organized and funded on a national basis by higher education institutions (e.g., universities). Community funding is used almost exclusively to foster mobility in education programs of EU interest. An outstanding example of the EU's funding instrument for education is the "Marie Curie" program (renamed PEOPLE [14]) under the current 7th Framework Program (FP-7) of the Community's Director General (DG) for Research.

Four principles have emerged out of the Euratom education strategy (ENEN):

- MODULAR COURSES AND COMMON QUALIFICATION APPROACH
  (coherent qualification methodology for the selection criteria of the modules)
- ONE MUTUAL RECOGNITION SYSTEM FOR MASTER GRADES
  (European Credit Transfer and accumulation System [ECTS] of ERASMUS)
- MOBILITY FOR TEACHERS AND STUDENTS ACROSS THE EU (and beyond)
  ("fifth freedom": free movement of knowledge and mutual recognition of diplomas)
- FEEDBACK FROM (SCIENTIFIC AND FINANCIAL) "STAKEHOLDERS".
  (listen to the needs of and involve the "future employers" in education programs).

The Euratom approach to nuclear training is aimed at a continuous increase of the level of nuclear competencies, while at the same time achieving the desired "free movement" of experts across the EU. More generally, the free movement of knowledge is called the "fifth freedom" in the EU global policy: it is complementary to the other "freedoms" of the internal market - the free circulation of people, goods, capital and services. The focus of ENEN and other parties concerned with nuclear competence building is on the design of "learning outcomes," in line with the ECVET.

In the context of ECVET partnerships, the instruments for mutual recognition are "Learning Agreements" and "Personal Transcripts." The "Learning Agreement" is signed by the Learner, the Home Institution and the Hosting Institution. It is an individualized document which sets out the conditions for a specific mobility period. For each particular learner, it specifies what outcomes s/he should achieve and how they will be assessed, validated and recognised. The Personal Transcript is a record of learning achievements. It contains information on learners' assessed outcomes, units and ECVET points awarded (whenever necessary). It also specifies the identity of the learner and the competent institution(s) that assessed, validated and recognized the learners' credit. This document will allow an individual to prove his or her nuclear competence in a coherent manner recognized by all employers across the EU.

In this context, a number of *Euratom Fission Training Schemes* (EFTS) were launched in specific areas where a shortage of skilled professionals has been identified (see Section 6). The EFTS is a significant development aimed at structuring training and career development across the EU. This is a long-term and ambitious program, spread over many years and relying on the active participation of all stakeholders concerned with nuclear competence building. The aim is to transfer knowledge, skills and attitudes in a number of key areas to different learners categories with higher education (including PhD student coaching, mentoring of new professionals, customer training, etc). Different techniques are used, such as regular versus virtual classroom training, face-to-face versus distance learning. The ultimate objective of each EFTS is to develop a European passport. Therefore, wherever appropriate, it is envisioned to use the above ECVET instruments in synergy with ENEN.

Training activities are usually organized and funded by the private sector. Community funding is used in a few selected areas of EU interest, in particular to foster industry–academia synergies, with special attention to the identification and mutual recognition of qualifications or portfolios of learning outcomes.

6. CONTINUOUS IMPROVEMENT AND RECOGNITION OF NUCLEAR COMPETENCIES: EURATOM FISSION TRAINING SCHEMES (TRASNUSAFE, ENEN III, ENETRAP II, PETRUS II)

Four Euratom FP-7 projects of the EFTS type are briefly discussed below. They are examples of competencies required by a number of stakeholders that are concerned with specific societal and industrial challenges. These FP-7 projects and their stakeholders are as follows:

- TRASNUSAFE: health physics sector (e.g., ALARA principle)
- ENEN III Training schemes : nuclear systems suppliers
- ENETRAP II: nuclear safety authorities (e.g., Radiation Protection Expert)
- PETRUS II: radwaste agencies (e.g., repository and engineered systems design).

(1) TRASNUSAFE : Nuclear Safety Culture

The focus in this EFTS is on competencies required by the health physics sector (e.g., ALARA principle). This FP-7 project aims at designing, developing and validating two training schemes on nuclear safety culture, with a common basis. One scheme is related to the nuclear industry and the other to installations making use of ionising radiation. The target public are professionals, at the managerial level, in charge of health physics control in nuclear power plants and of radiotherapy services in hospitals.

The general objective of TRASNUSAFE includes the four following specific objectives:

- an analysis of the training needs across Europe
- a common approach with respect to the ALARA principle currently used in the radiation protection community and the safety culture of the nuclear industry
- a common generic basic module for the two training schemes, and four specialized modules
- testing and validation of the training schemes by means of pilot sessions.

The 19 Participants are: UCL (B) as coordinator, Tecnatom (E); SCK•CEN (B); ITN (P); JSI (SLO); CEPN (F); EAN (EU); UPB (RO); Uniman (UK); Stuba (SK); Cirten (I); UPM (E); NDDACMT (UK); ENEN association (INSTN, TKK, BME); CNCAN (RO); Tractebel ENG. (B); EITA (EU); SNN (RO); SEAS (SK).

(2) ENEN III Training schemes: Generation III and IV engineering

Here, the focus is on competencies required by nuclear system suppliers. This EFTS aims at organizing four training schemes:

- Basic Nuclear Topics for Non-Nuclear Engineers
- Design Challenges for Generation III NPP (2 professional profiles)
- Construction Challenges for Generation III NPP (2 professional profiles)
- Design Challenges for Generation IV Reactors.

Special attention is devoted to the following competencies: System and Process Engineering, Safety Analysis Evaluation, HVAC Project Implementation, digital I&C Engineering. A number of internships with different stakeholders are organized in order to

confront the trainees with the different policies and cultures of employers in various EU countries. The focus is on the acquisition of responsibility and autonomy under the mentorship of employers.

The 19 Participants are: ENEN Association as coordinator, SCKCEN, UCL, TKK, LUT, INSTN, Areva, ISAR, BME, Cirten (Polito, Unipi), DUT, UPB, UL, JSI, Tecnatom, UNED, UPM, UPC, Sultan.

(3) ENETRAP II - European Network on E&T in Radiological Protection

This EFTS focuses on competencies required by nuclear safety authorities (e.g., Radiation Protection Expert

– 96/29/Euratom Directive).

In this FP-7 project, special attention is devoted to the following issues:

– "supply" of a high-quality European standards for initial education and continuous professional development for radiation protection experts (RPEs) and radiation protection officers (RPOs)

– development of the "European radiation protection training scheme" (ERPTS) for RPE training; the legal basis is the Euratom legislation on Basic Safety Standards (96/29/Euratom) and forthcoming revision (including "RPE Recognition").

The Radiation protection expert (RPE) is defined as follows: an individual having the knowledge, training and experience needed to give radiation protection advice in order to ensure effective protection of individuals whose capacity to act is recognized by the competent authorities.

The 12 participants are: SCK•CEN, Belgium as coordinator; CEA-INSTN, France; KIT-FTU, Germany; BfS, Germany; ENEA, Italy; NRG, The Netherlands; Ciemat, Spain; HPA-CRCE, UK; ENEN Association (TKK, ISAR), France; ITN, Portugal; BME-NTI, Hungary; UPB, Romania.

(4) PETRUS II: Program for Education, Training, Research on Underground Storage

The focus here is on competencies required by radwaste agencies (e.g., repository and engineered systems design). In this EFTS, a Science and Technology Passport is being developed, related to the following competencies: Site Investigation Design and Management; Underground Construction; Repository and Engineered Systems Design; Above Ground Waste Handling Facility Design/Operation; Underground Systems Engineering (Waste Handling); Operational and Post-Closure Safety.

A preliminary survey of the "market" showed that a number of Training Courses do exist in the areas mentioned in the above Science and Technology Passport, spread across the EU. To complete the passport, a series of new courses will be organized in the Euratom framework. The existing courses are as follows (France, Switzerland, Germany, United Kingdom, Sweden, Finland and Slovenia): Natural Analogues (Ecole des Mines de Nancy); From Surface Based to Underground Site Characterisation (ITC School) ; Petrology and Geochemistry of rocks relevant for final disposal (TU Clausthal) ; Numerical Modelling (Cardiff University); Microbial and Disposal of Radioactive Waste (Microbial Analytics, Sweden AB); Introduction to the fundamentals of safety assessment in GD Safety (Posiva Oy); Assessment of Deep Geological Repository (RAWRA).

The 14 participants are: Institut National Polytechnique de Lorraine, FR, as coordinator; ANDRA, FR; ARAO, SI; Cardiff University, UK; Enresa, ES; ENEN Association (UPM, CTU, TKK, BME), FR; GRS, DE;ITN, PT; ITC School of Underground Waste Storage and Disposal, CH; Microbial Analytics Sweden AB, SE; NDA, UK; Posiva Oy, FI; RAWRA, CZ; Universitaet Clausthal, DE.

7. CONCLUSION: TOWARD ECVET PARTNERSHIPS IN FISSION AND RADIATION PROTECTION

According to the IAEA/INSAG, *safety depends on several factors: technology, an appropriate legal framework, an effective national regulatory body, and the existence of a safety culture throughout government and industry*. In this paper, it is demonstrated that Euratom training programs deal effectively with safety culture, as is required in the operation of reactor systems, in waste management activities and in medical and industrial applications where radiation protection is necessary.

It is shown, in particular, that the Euratom training strategy is based on three objectives, involving all stakeholders:

- analysis of the *needs of society and industry* with regard to a common safety culture.
- convergence toward a *common approach* that puts those needs in an EU perspective.
- development of *common instruments* that meet the above needs and vision (ECVET).

The recommended instrument is the *European Credit system for Vocational Education and Training* (ECVET), due to be implemented by Member States by 2012. The focus is on the design of "learning outcomes" which should in principle be achievable through a variety of education and training paths (be it in a formal, non-formal or informal context) for individuals who are following a learning process to acquire specific competencies in a nuclear sector.

One of the most urgent needs is to establish a common language for competencies and education and training related to nuclear fission and radiation protection (a common "taxonomy"). Special efforts should be devoted to the definition of "learning outcomes" that are recognized throughout the EU, and thereby facilitate borderless and lifelong learning. "Competent Institutions" or "Competent Bodies" should also be identified; they are responsible for designing and awarding qualifications or recognizing learning outcomes, under the rules and practices of participating countries.

Of particular interest for the nuclear community is the development of ECVET partnerships, based on "Learning Agreements" and "Personal Transcripts". All this is discussed in dedicated FP-7 projects (*Euratom Fission Training Schemes* /EFTS), related to various sectors:

- the health physics sector (e.g., ALARA principle) / TRASNUSAFE project
- the nuclear systems suppliers (e.g., construction challenges for GEN III) / ENEN III
- the nuclear safety authorities (e.g., Radiation Protection Expert) / ENETRAP II
- the radwaste agencies (e.g., repository and engineered systems design) / PETRUS II.

The nuclear stakeholders, concerned with human resources and professional recruitment, are invited to design, assess and mutually recognize portfolios of learning outcomes, with a view to developing high level competencies of common interest. ECVET partnerships between Home and Hosting Institutions should be formed, aiming at facilitating borderless and lifelong learning for a new generation of highly qualified professionals. ENEN plays a key role in this networking process. The first ECVET experiences were discussed at the FISA-2009 Conference, organized by DG Research / Euratom (Prague, 22 -26 June) [15] .

In conclusion, Euratom research and training activities contribute not only to the creation of knowledge but also to competence building (where skills and attitudes come on top of knowledge). The ECVET instruments, developed by DG EAC (Leonardo da Vinci), seem particularly promising in improving existing or

developing new nuclear competencies and qualifications, while ensuring mutual recognition of a new generation of international experts.

The participation of the main stakeholders (e.g., SNE-TP) is particularly appreciated in this competence-building process, involving VET providers and academia throughout the EU.

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Hacia una cultura de seguridad nuclear común: desde la creación de conocimientos hasta el desarrollo de competencias en los programas de Euratom

RESUMEN Y PUNTOS CLAVES

Los programas de investigación y formación de Euratom tienen como uno de sus objetivos principales contribuir a la sostenibilidad de la energía nuclear mediante la dotación de recursos, en particular para la investigación e innovación en las Generaciones II, III y IV (creación de conocimientos). Los programas de formación de EURATOM contribuyen de forma más notable al desarrollo de competencias, a la vez que facilitan el reconocimiento mutuo de expertos, permitiendo así la mejora continua de la cultura de seguridad nuclear. La Plataforma Tecnológica para la Energía Nuclear Sostenible (SNE-TP), constituida por todos los grupos de interés en la fisión nuclear y la protección radiológica (más de 75 organizaciones), es una fuerza impulsora de los mismos.

El enfoque de este artículo es el desarrollo de competencias nucleares bajo el actual 7o Programa Marco de EURATOM (2007 – 2013). Naturalmente los empleadores (en particular, la industria nuclear y las organizaciones técnicas de seguridad) están involucrados en este proceso. Según la definición del OIEA, competencia significa la capacidad de aplicar conocimientos, habilidades y actitudes con el fin de realizar un trabajo de forma eficaz y eficiente y de acuerdo con una norma establecida (S.S.S. N1 RS-G-1.4 / 2001). Se suelen crear conocimientos en las instituciones de educación superior (p.ej., las universidades) y en organizaciones de investigación tanto privadas como públicas. Normalmente las habilidades y las actitudes son el resultado de una formación específica y de la experiencia acumulada en el trabajo a lo largo de la vida profesional.

Tradicionalmente las actividades de formación de Euratom están destinadas a los científicos y expertos con estudios superiores. Se presta especial atención a la mejora continua de sus competencias a través de la movilidad sin fronteras y de la formación continuada en sinergia con los grupos de interés principales. La estrategia de formación de EURATOM se basa en tres objetivos:

1 – El análisis de las necesidades de la sociedad y de la industria en cuanto a una cultura de seguridad nuclear común. Este tema plantea cuestiones importantes, por ejemplo: ¿Qué es lo que se debe añadir a los esquemas de formación existentes? ¿Cómo se podría mejorar el Desarrollo Profesional Continuo (CPD)? ¿Es importante la movilidad y el reconocimiento mutuo de expertos? (especialmente en los ámbitos de la seguridad y rendimiento de reactores; gestión de residuos; y las aplicaciones médicas de las radiaciones ionizantes).

2 – La convergencia hacia una visión común que permite abordar las necesidades arriba indicadas desde una perspectiva de la Unión Europea (UE), lo que significa, por ejemplo: fijar objetivos ambiciosos en la nueva estrategia de CPD y a la vez satisfacer obligaciones difíciles (p.ej., mejora continua de la sostenibilidad, seguridad y fiabilidad, rendimiento económico y resistencia a la proliferación de la energía nuclear – que también son los cuatro objetivos en los que se basa la estrategia del Foro Internacional Generación IV /GIF/).

3 – El desarrollo de instrumentos comunes que satisfacen las necesidades y la visión arriba mencionadas (ECVET). Para ello es necesario, por ejemplo: una "taxonomía" común de competencias vinculadas con las tareas en la industria nuclear; la definición de "resultados de formación" que son reconocidos en toda la UE, facilitando así la formación continuada y sin fronteras; la identificación de "instituciones competentes" para establecer portfolios de los resultados de formación necesarios para realizar dichas tareas.